Moravian stations, we now have some definite information from Lieut. Gordon's report of the Hudson's Bay expedition of 1884. He says: "I cannot help thinking that their numbers have sensibly diminished, inasmuch as we found signs of their presence everywhere; yet except at Port Burwell, Ashe inlet and Stupart's bay, none were met with. About six miles south of Port Burwell [Cape Chudleigh] there are the remains of what must once have been a large Eskimo settlement, their subterranean dwellings being still in a fair state of preservation. At the present time, so far as I can learn, there are only some five or six Eskimo families between Cape Chudleigh and Nachvak.

"Along the Labrador coast the Eskimo gather in small settlements round the Moravian Mission stations; at these places their numbers vary considerably. Nain is reported to be the largest settlement, and its Eskimo population amounts to about 200 souls" (p. 16).

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THE INTER-RELATIONSHIPS OF ARTHROPODS.

BY J. S. KINGSLEY.

IN most of the schemes of classification in vogue to-day the Arthropods are divided into two groups of equal rank, the first being the Crustacea, the second embracing the Tracheata or Insecta. Having recently studied the embryology of Limulus, and finding it necessary to ascertain its place among the arthropods, the writer was led to compare, in a critical manner, the various groups. This led to somewhat unexpected views as to the various inter-relationships of the different "types" (if that word may be pardoned), and as the results may prove of interest, a short résumé is here presented in advance of the full article which will appear in the *Quarterly Journal of Microscopical Science* for October.

It might be stated here, parenthetically, that upon a large number of points regarding the arthropods, and especially the so-called tracheates, our knowledge is extremely deficient. For this reason some of the following account is merely tentative, the probability being in favor of the views here adopted.

First, we may take up the relationship of Limulus to the spiders. The view first suggested by Strauss-Dürckheim and lately so ably supported by Professor E. Ray Lankester, that Limulus is not a crustacean but an arachnid, receives full confirmation from the

development of the king-crab. The introduction of this form into this group seems to necessitate a new term for the whole, and I have adopted the name Acerata for the arachnids and the merostomes, in reference to the absence of antennæ. It is but a slight modification of the word Acera, used many years ago by Latreille for the spiders alone. The term Arachnida still retains its former significance.

As here limited, the Acerata may be defined as arthropodous animals with the body divided into two regions (cephalothorax and abdomen), the cephalothorax bearing six pairs of primitively post-oral appendages. The number of abdominal appendages vary, but four or more are modified for respiratory purposes; respiration being performed by gills, "lungs" or tracheæ, the homology between these three types of organs being easily traced. The genital ducts empty at the base of the seventh (first abdominal) appendages and paired segmental organs open, in the young, at the base of the fifth pair of limbs, but lose their excretory duct in the adult. The genital glands are branched and the branches communicate through numerous anastomoses. The liver is large and voluminous. The development is direct, no metamorphosis being introduced.

Some of these points may require explanation, and while I would refer the reader to the paper on the embryology of Limulus for details, I may here mention a few facts. My studies on the development of the gills of the king-crab when compared with those of Metschnikoff on the scorpion and those of Salensky on the spiders, show that the lungs of the one and the gills of the other are (as was suggested by Lankester) perfectly homologous. They arise as foldings at the base of appendages, occupying the same position serially in both Limulus and the scorpions. Leydig showed, some thirty years ago, that the tracheæ and pulmonary sacs of the spiders were homologous organs, and in later years the same has been pointed out by Bertkau and Macleod. One very important point should here be noted. In the spiders the stigmata or external openings of the tracheæ or pulmonary sacs never occur elsewhere than on the abdomen, and they always perforate the sternal plates. In the hexapods they occur in all parts of the body, and always on the sides and never on the ventral surface.

The so-called coxal glands or, as I regard them, segmental

organs, have only recently been known. Packard first found them in Limulus, and later Lankester made an exhaustive histological study of them in comparison with similar glands occurring in the scorpions. Neither of these authors were able to find any external duct. More recently Bertkau has found that in the young spider they open externally at the base of the fifth pair of appendages (third pair of legs), but this duct is lost in the adult. The studies of Mr. Michael on the coxal glands of mites are, so far as they go, confirmative. In Limulus I found that they arose as coiled mesoblastic tubes, closely comparable to the segmental organs of worms, and emptied in the young at exactly the same point as in spiders.

It seems to me that these various points show that the Acerata are more closely allied to the Crustacea than to the hexapods and myriapods with which they are usually classed. Lankester has shown from a study of Apus that all of the crustacean appendages are primitively post-oral, a fact which is confirmed by the study of the development of various forms. With this point settled it would appear that we have a perfect right to compare, within certain limits, the segments and their appendages of spiders and crustaceans. Tabularly arranged, the result would be somewhat as follows:

CRUSTACEA.	ACERATA.
I. Antennula.	Chelicera.
II. Antenna.	Pedipalpus.
III. Mandible,	Leg I.
IV. Maxilla 1.	Leg II.
V. Maxilla 2.	Leg III.
VI. Maxilliped 1,	Leg IV.

That this serial comparison is legitimate is shown by several reasons besides that given above. In the Acerata the series embraces all of the cephalothoracic appendages. In the Crustacea it stops exactly at the line of division between the so-called head and thorax of the tetradecapods as well as in the embryos of many other forms. A further point is interesting. In many of the lower Crustacea a pair of so-called shell glands occur which are regarded by Claus, Grobben and others as comparable to the segmental organs of worms. The outlets of these organs occur at the bases of the second pair of maxillæ, a position which the above table will show is exactly comparable to that of the outlet of the coxal glands of Limulus and the spiders. In many Crus-

tacea another pair of glands occur, the antennal or green glands which also appear to belong to the same series.

A further point is also to be mentioned. In both Acerata and Crustacea the genital ducts open at the base of a pair of appendages near the middle of the body, and although that exact homology is lacking as to position which is seen in the case of the segmental organs, still there is enough similarity to make one think that here, as well as in other forms, a pair of segmental ducts has become modified to subserve the purposes of the genital system.

Did space allow, these comparisons could be prolonged almost indefinitely, showing that while there is a general resemblance between the Acerata and the Crustacea, there exists a much closer one between Limulus and the arachnids. If we turn now to a comparison of the Acerata, or even the arachnids proper, with the hexapods, we are at once struck with the important differences between them ; differences which prove that the two groups have but little in common, and that, so far as these two are concerned, the division Tracheata is an artificial and not a natural one.

We have already alluded to one important difference between the tracheæ in the two groups. A few other remarks may prove of value. Tracheæ are internal tubes for conducting air to the tissues of the body. They are not confined to the "Tracheata" but occur in some of the terrestrial Crustacea. This was first pointed out by Lereboullet in 1851 in the sow-bugs (Oniscidæ), and more lately it has been shown that these tracheæ which are developed inside the branchial lamellæ are lined with a cuticle which is raised into folds, comparable to the so-called spiral filament in the tracheæ of the hexapods. The inference to be drawn is that tracheæ in the arthropods are not of phylogenetic significance, but have arisen from a necessity of conveying air to the blood and tissues in an air-breathing form. The thickenings of the cuticular wall, whether spirally or irregularly arranged, are intended to prevent the collapse of an otherwise delicate tube.

In both spiders and hexapods there are developed from the hinder division of the digestive tract excretory organs which are known as urinary or Malpighian tubules. The writer holds that these are not to be regarded as indicating any especial affinity between the two groups, but like the tracheæ are produced by

environment; though it must be admitted that the reason why a terrestrial life should cause the development of these organs is not as easily explained as in the case of the tracheæ. In proof, however, of the point made, it may be stated that in those amphipods which like Gammarus and Orchestia are more or less terrestrial in habit, similar tubes are developed from the same portion of the alimentary canal, and further that their size and length is directly proportional to the more or less terrestrial habits of these forms. The same is apparently true of some of the isopods, though on this point our information is deficient.

Another point usually emphasized is the fact that in the Crustacea a biramose condition of the appendages occurs while this is not known in the "tracheates." The studies of Lankester on Apus have shown how this biramose condition arose, and the fact that frequently it is lacking in the Crustacea would tend to indicate that it might have existed in the ancestors of the "tracheates" and have been lost in the present forms. Even more important is the fact that such structures are not unknown in the "tracheates." They occur, as James Wood-Mason has shown, in the thysanures, and Patten has described a similar state of affairs in the embryos of the cockroach.

So far as our present knowledge goes we can say nothing as to the primitive position of the antennæ of hexapods; whether they be processes of the procephalic lobes somewhat like those of Peripatus or appendages which originally belonged to the post-oral series and which have moved forwards to a pre-oral position as have the similarly named appendages of the Crustacea. In the former case the differences in this respect between the hexapods on the one hand and the Crustacea and Acerata on the other will be seen to be very great. If the other view prove to be the true one, these organs of course will have less importance from a taxonomic standpoint. Still the differences will be very marked. That the former view is correct I am inclined to believe. If we accept it and regard the antennæ as something entirely represented in spiders and Crustacea and then make a serial comparison as before, the result is as follows:

HEXAPODA.	ACERATA.
I. Mandibles.	Chelecera.
II. Maxilla.	Pedipalpus.
III. Labium.	Leg I.
IV. Leg I.	Leg II.
V. Leg II.	Leg III.
VI. Leg III.	Leg IV.

This comparison brings the beginning of the abdomen in the same position in each group, but we have no other features to test its validity as we had in the case of the Acerata and Crustacea. In the hexapods there is nothing which in any way resembles a segmental organ.

The hexapods have no liver, an organ voluminously developed in Acerata and Crustacea; their genital ducts terminate at the end of the body, and no evidence as yet presented points to the conclusion that they are to be regarded as modified segmental organs.

With regard to the myriapods the problem is more difficult, and our knowledge of the development is too scanty to throw much light on the subject. The attempt has often been made to homologize the mouth parts in the two groups, but as yet with not very satisfactory results. A few morphological facts may prove suggestive. As is well known the myriapods are divided into two groups, Chilopoda and Chilognatha, represented by Scolopendra and Julus respectively. In the Chilopoda the genital ducts terminate at the end of the body beneath the anus, in the chilognaths near the anterior end of the body, in a position almost comparable to that in the Acerata. In the chilopods the stigmata occupy the same position (between the dorsal and ventral plates) as in hexapods, but in the chilognaths they may occur on the ventral plates or even in the bases of the legs. Apparently in both groups the antennæ are pre-oral in position; in the chilognaths their nerves arise in advance of those to the optic organs.

In this connection more knowledge, especially of the head, is desirable concerning the curious fossil myriapod, Acantherpestes, described by Mr. Scudder. Scolopendrella will also repay investigation. In these forms, between the bases of the legs are the openings of peculiar organs. Mr. Ryder regarded those of Scolopendrella as tracheal stigmata; Mr. Scudder those of Acantherpestes as supports for branchiæ. It may turn out, indeed it is probable, that both are the outlets of segmental organs.

The few facts here presented, when taken together with the preceding remarks on tracheæ and Malpighian tubes, would allow the supposition that the myriapods may have but little relationship with either hexapods or spiders, and even that chilopods and chilognaths are not so closely connected as is usually supposed.

The discovery by Moseley of tracheæ in Peripatus at once transferred this form to the tracheate phylum, and much was expected from it as throwing light on the origin of the other air-breathing arthropods. To the writer it does not appear to have any close relationship to any of the other "tracheata," but still most of all to the chilognaths. Still it is not proven beyond a doubt that it is an arthropod at all.

The so-called antennæ are always pre-oral (as shown by Kennel in the embryo and Balfour in the adult), and receive their nerve supply from the procephalic lobes in advance of these nerves to the eyes; thus allowing one to compare them with the preoral appendages of worms. The tracheæ and stigmata are not metamerically arranged, the latter opening more or less irregularly over the surface of the body and legs. The legs themselves are not distinctively arthropodous, while the numerous segmental organs indicate, as has often been pointed out, a very primitive form. Indeed, one has but to imagine a Syllid worm to leave its natural element and take to the land, losing the setæ of its parapodia and developing claws at their extremities, losing its median antennæ and developing tracheal pits for respiration and salivary glands to moisten its food, and Syllis becomes Peripatus. The other changes would be few. It would still retain its lateral tentacles, its segmental organs, its peculiar sympathetic nervous system and many details of its digestive tract. In fact Peripatus, in the light of recent studies, appears nearer the polychætous annelids than to any of the arthropods unless possibly the chilognathous myriapods.

Recapitulating now the results of this hasty sketch, we arrive at the following conclusions: Peripatus has departed the least from the ancestral annelidan stock, the hexapods the farthest. These then will form the extremes of the series. The Acerata and Crustacea should be placed near each other, but which is the higher is a question. For instance, in the one only one pair of segmental organs remains, and these have lost their external ducts, while in the other group two pairs of these organs are functional through life. On the other hand, two of the post-oral ganglia of the Crustacea have moved to a prestomial position and have joined the supra-œsophageal ganglion, while in the Acerata but one ganglion has been completely transferred and this has not yet become wholly united with the ganglion formed

by the procephalic lobes. The position to be occupied by the myriapods can only be decided by further study.

As will be seen, the points requiring further investigation are many. We at the same time know more and less of the arthropods than of any other group of the animal kingdom, unless it be of the birds. The literature descriptive of the species of insects is enormous, but when one tries, for the purpose of exact comparison, to find out from books some of the simplest points of tracheate anatomy, he is met with only vague and generalized statements or with no information at all. It may be that further study will show that the conclusions reached above are founded on insufficient data, but we think it must be admitted that so far as Crustacea, Arachnida, Limulus and the hexapods are concerned, the points here made are well sustained by our present knowledge. What is especially needed is a more exact knowledge of the arthropodan brain. The papers of Newton, Dietl, Flögel, Brant and others are good, so far as they go, but unfortunately they leave many and the most important points undecided. The same may be said of almost every other point in arthropodan anatomy except the morphology of the appendages, and even on this point much work remains to be done.

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HOW THE PITCHER PLANT GOT ITS LEAVES.

BY JOSEPH F. JAMES.

OF the many curious plants which have been given to the world by America, the pitcher plants are among the oddest. They form a family which belongs entirely to the new world, where the species are widely dispersed. One of them is found in South America, one in California, while the others are natives of the Atlantic seaboard. A single one of these extends northwestward to Minnesota and British America. The feature which is common to these widely-scattered forms is the hollow leaf, making a sort of pitcher into which insects fly or fall or walk.

When a leaf departs as far from the normal shape as does the leaf of the Sarracenia, it is always interesting work to try to discover the causes which have lead to the divergence. To do this it is necessary to go far back in the history of the world and find an ancestral leaf from which it could have come. This necessitates the examination of the various allies and relatives of the